

**(19) World Intellectual Property Organization**  
International Bureau



**(43) International Publication Date**  
**15 November 2001 (15.11.2001)**

## PCT

**(10) International Publication Number**  
**WO 01/85386 A3**

(51) **International Patent Classification<sup>7</sup>:** **B29C 67/00.**  
B22F 3/105, B23K 26/34, B05B 7/14

(21) **International Application Number:** PCT/US01/11753

(22) **International Filing Date:** 7 May 2001 (07.05.2001)

(25) **Filing Language:** English

(26) **Publication Language:** English

(30) **Priority Data:**  
09/568,207 9 May 2000 (09.05.2000) US

(71) **Applicant: OPTOMECH DESIGN COMPANY [US/US]:**  
Ned Godshall, President, 3911 Singer Boulevard, NE, Albuquerque, NM 87109 (US).

(72) **Inventors: KEICHER, David, M.:** 5309 Hines NE, Albuquerque, NM 87111 (US). **LOVE, James, W.:** 1344 Rio

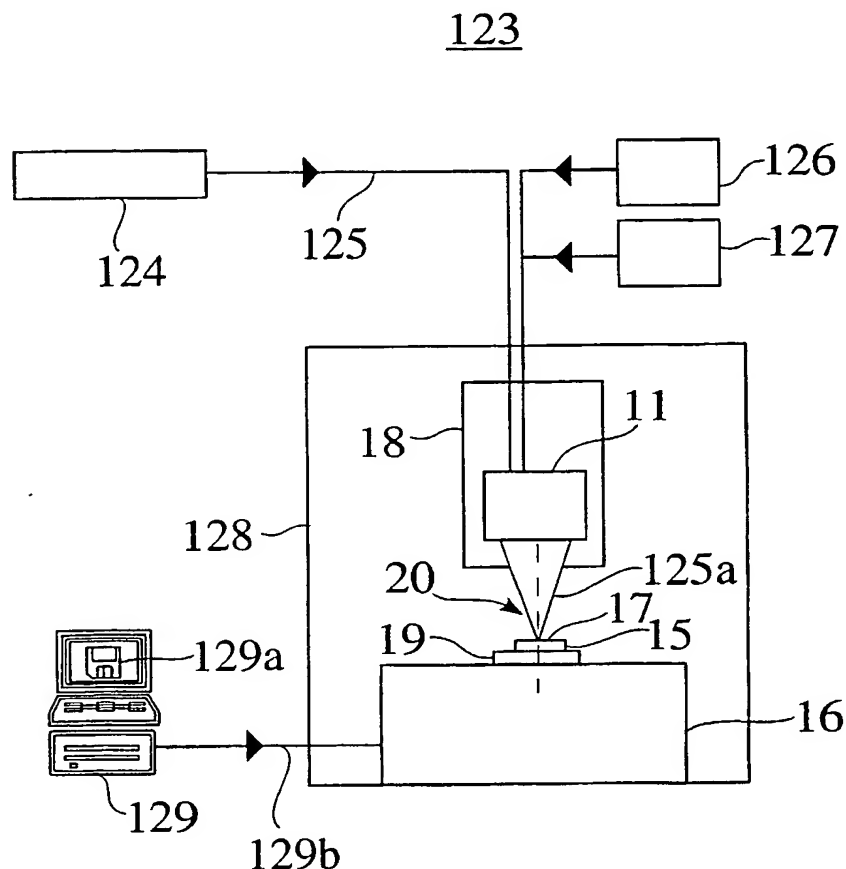
Grande, Los Lunas, NM 87031 (US). **DULLEA, Kevin, J.**: 5226 Carlsbad Court NW, Albuquerque, NM 87120 (US). **BULLEN, James, L.**: P.O. Box 2136, Edgewood, NM 87015 (US). **GORMAN, Pierrette, H.**: 8 Trigo Road, Placitas, NM 87043 (US). **SMITH, Mark, E.**: 30 Shady Oak Circle, Tijeras, NM 87059 (US).

(74) Agent: **GIACCHERINI, Thomas, Nello**; P.O. Box 1146, Carmel Valley, CA 93924 (US).

**(81) Designated States (national):** AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, ME, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW.

*[Continued on next page]*

**(54) Title:** FORMING STRUCTURES FROM CAD SOLID MODELS



**(57) Abstract:** Method and apparatus for embedding features and controlling material composition in a three-dimensional structure (130) are disclosed. The apparatus comprises a directed material deposition apparatus having a source (124) of a focused laser beam, a deposition head (11) being coordinated in a plurality of coordinate axes, a controlled atmosphere chamber (128), a control computer (129), a plurality of feedstock (126, 127), a design rendering a solid model including embedded features, and a positioning stage (16) with a substrate (19) disposed on it. Said deposition head (11) can be a multi-axis deposition head, with a volumetric powder feed unit, a rapid acting metering valve for powder feedstock control, a laser delivery system having an optical fiber with heat protection, a laser beam shutter dump assembly and a plurality of powder delivery nozzles comprising coaxial gas stream means for reduced powder dispersion. Material properties can be engineered by adjusting laser exposure, material deposition and material constants.

**WO 01/85386 A3**



(84) **Designated States** (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

(88) **Date of publication of the international search report:**  
16 May 2002

*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

**Published:**

— with international search report

# INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 01/11753

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 B29C67/00 B22F3/105 B23K26/34 B05B7/14

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 B29C B22F B23K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EP0-Internal, WPI Data, PAJ

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 97 16274 A (MASSACHUSETTS INST TECHNOLOGY) 9 May 1997 (1997-05-09)	1,2,8, 13-18,44
Y	the whole document	3,4,19
Y	TAKASHI NAKAI ET AL: "FABRICATION OF THREE-DIMENSIONAL OBJECTS USING LASER LITHOGRAPHY" SYSTEMS & COMPUTERS IN JAPAN, SCRIPTA TECHNICA JOURNALS. NEW YORK, US, vol. 20, no. 3, 1 March 1989 (1989-03-01), pages 58-66, XP000071510 ISSN: 0882-1666 page 59, paragraph 2.2 - paragraph 2.3	3
X	WO 92 18323 A (HABER MICHAEL B) 29 October 1992 (1992-10-29)	45,46
Y	claim 2; figures	4,19

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

### \* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

27 September 2001

Date of mailing of the international search report

18.01.2002

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,  
Fax: (+31-70) 340-3016

Authorized officer

MATHEY, X

# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US 01/11753

## Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:  
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
3. ☐ Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

## Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-4, 8, 13-23, 44-46

### Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.

## FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-4,8,13-23,44-46

1.1. Claims: 1-3,18

A three dimensional modeling method or apparatus by directed material deposition in which a provision is made for embedding features, including adjusting layer thickness according to ratio of irradiance of laser beam to velocity of said laser beam in a x-y axis.

1.2. Claims: 4,19-23,45,46

A three dimensional modeling method or apparatus by directed material deposition in which a deposition head is capable of movements in a plurality of linear directions as well as in at least one rotational direction.

1.3. Claims: 8,13-17,44

A method or apparatus to produce a complex three dimensional structure by directed material deposition on a substrate, in which a provision is made for a substructure used to control thermal characteristics of the finished three dimensional object.

2. Claim : 5

A three dimensional modeling method or apparatus by directed material deposition in which a provision is made for embedding features including adjusting layer roughness according to particle size and irradiance of laser beam.

3. Claims: 6,7,24-43

A three dimensional modeling method or apparatus by directed material deposition on a substrate, in which a provision is made for embedding features and including applying heat to the substrate according to a temperature profile.

4. Claims: 9-12

A three dimensional modeling method or apparatus by directed material deposition on a substrate, in which a provision is made for embedding features and including depositing a buttering layer between dissimilar metals being joined.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

5. Claim : 47

A valve apparatus for controlling the flow of a powder and a carrier gas

6. Claims: 48,49

A powder feeder apparatus with a rotating feed plate member

7. Claims: 50,51

A direct material deposition apparatus wherein a laser beam is directed at a substrate at a slight deviation from the normal to the substrate

8. Claim : 52

A direct material deposition apparatus with means for dissipating the laser beam

9. Claim : 53

A direct material deposition process for producing a structure with an overhanging edge

10. Claim : 54

A direct material deposition apparatus with means to reduce dispersion in a gas entrained powder delivery system

Please note that all inventions mentioned under item 1, although not necessarily linked by a common inventive concept, could be searched without effort justifying an additional fee.

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 01/11753

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9716274 A	09-05-1997	US 5775402 A	07-07-1998
		EP 0862507 A	09-09-1998
		JP 11515058 T	21-12-1999
		US 6112804 A	05-09-2000
		US 5814161 A	29-09-1998
-----			
WO 9218323 A	29-10-1992	JP 6509523 T	27-10-1994
-----			

**THIS PAGE BLANK (USPTO)**